

C4176 Log Data Report

Borehole Information:

Borehole: C4176		Site: 216-S-20 Crib			
Coordinates (WA State Plane)		GWL (ft)¹: Dry		GWL Date: 09/13/2004	
North	East	Drill Date	TOC² Elevation	Total Depth (ft)	Type
Not available	Not available	09/13/2004	Not available	245	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Carbon Steel	0.25	10 3/4	9 3/4	1/2	0.25	55.0
Carbon Steel	0.75	8 5/8	7 5/8	1/2	0.75	245.0
Casing depths were reported by the driller. The logging engineer used a caliper and steel tape to measure outside and inside casing diameters. All measurements were rounded to the nearest 1/16 in.						

Borehole Notes:

Zero reference is the ground surface. The borehole was drilled in two stages. Stage 1 was drilled to 55 ft on August 26, 2004, using 10-3/4-in. outer diameter (OD) casing. After logging, the borehole was extended to 245 ft, using 8-5/8-in. OD casing inside the larger casing to isolate the near-surface contamination.

Logging Equipment Information:

Logging System:	Gamma 4E	Type:	70% HPGe (34TP40587A)
Calibration Date:	05/2004	Calibration Reference:	DOE/EM-GJ692-2004
	Logging Procedure: MAC-HGLP 1.6.5, Rev. 0		

Logging System:	Gamma 2F	Type:	NMLS (H380932510)
Calibration Date:	09/2003	Calibration Reference:	GJO-2003-520-TAC
	Logging Procedure: MAC-HGLP 1.6.5, Rev. 0		

Logging System:	Gamma 1C	Type:	"Planar" HPGe (39A314)
Calibration Date:	09/2004	Calibration Reference:	DOE/EM-GJ713-2004
	Logging Procedure: MAC-HGLP 1.6.5, Rev. 0		

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2-repeat	3	4-repeat	5
Date	08/26/04	08/26/04	09/14/04	09/15/04	09/15/04
Logging Engineer	Kos	Kos	Pearson/Spatz	Spatz	Spatz
Start Depth (ft)	53.0	22.0	241.0	87.0	66.0
Finish Depth (ft)	0.0	17.0	66.0	67.0	52.0
Count Time (sec)	100	100	100	100	100
Live/Real	R	R	R	R	R
Shield (Y/N)	N/A ³	N/A	N/A	N/A	N/A
MSA Interval (ft)	1.0	1.0	1.0	1.0	1.0
ft/min	N/A	N/A	N/A	N/A	N/A
Pre-Verification	DE281CAB	DE281CAB	DE331CAB	DE341CAB	DE341CAB
Start File	DE281000	DE281054	DE331000	DE341000	DE341020
Finish File	DE281053	DE281059	DE331175	DE341020	DE342035
Post-Verification	DE281CAA	DE281CAA	DE331CAA	Not collected	Not collected
Depth Return Error (in.)	N/A	0.25	-1.5	N/A	
Comments	Fine gain adjustment after file -DE281003.	No fine gain adjustments.	No fine gain adjustments.		

Log Run	9	10 - repeat			
Date	09/28/04	09/29/04			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	240.4			
Finish Depth (ft)	235.0	220.0			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N/A	N/A			
MSA Interval (ft)	1.0	1.0			
ft/min	N/A	N/A			
Pre-Verification	DE381CAB	DE391CAB			
Start File	DE381000	DE391000			
Finish File	DE381235	DE391021			
Post-Verification	DE381CAA	DE391CAA			
Depth Return Error (in.)	0.0	1" low			
Comments	Fine gain adjusted after files DE381119, -168, -201 & -222.	No gain adjustments.			

Neutron Moisture Logging System (NMLS) Log Run Information:

Log Run	6	7	8-Repeat		
Date	09/20/04	09/20/04	09/20/04		
Logging Engineer	Spatz	Spatz	Spatz		
Start Depth (ft)	50.0	166.0	217.0		
Finish Depth (ft)	167.0	237.0	237.0		
Count Time (sec)	N/A	N/A	N/A		
Live/Real	R	R	R		
Shield (Y/N)	N/A	N/A	N/A		
MSA Interval (ft)	0.25	0.25	0.25		
ft/min	1.0	1.0	1.0		
Pre-Verification	BF180CAB	BF180CAB	BF180CAB		
Start File	BF180000	BF180469	BF180754		
Finish File	BF180468	BF180753	BF180834		
Post-Verification	BF180CAA	BF180CAA	BF180CAA		
Depth Return Error (in.)	N/A	N/A	-2		
Comments	None	Data directory change.			

High Rate Logging System (HRLS) Log Run Information:

Log Run	11	12 - repeat			
Date	10/07/04	10/07/04			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	33.0	32.0			
Finish Depth (ft)	22.0	28.0			
Count Time (sec)	300	300			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
ft/min	N/A	N/A			
Pre-Verification	AC112CAB	AC112CAB			
Start File	AC112000	AC112012			
Finish File	AC112011	AC112016			
Post-Verification	AC112CAA	AC112CAA			
Depth Return Error (in.)	N/A	-1			
Comments	No fine gain adjustment.	No fine gain adjustment.			

Logging Operation Notes:

On September 14, 2004, the logging engineer detected contamination on the sonde. Radiological surveys conducted on September 15 detected contamination on the wipes used to clean the logging sonde and cable and on the gloves and clothing of a logging engineer. Subsequent investigation indicated that the contamination originated in borehole C4671 (at the 216-A-4 Crib) and not in this borehole. A more detailed discussion of the contamination incident is presented in an attached report.

The presence of contamination on the sonde affected the analysis results of the data obtained on September 14. The borehole was re-logged on September 28 to collect more reliable data. After the inner 8-in. casing was removed, the high rate system was used to collect data in the interval from 22 to 33 ft.

Casing conditions during logging are summarized in the table below:

Event	Dates	Log Run(s)	Depth (ft)	Casing Thickness (in.)
SGLS - A	Aug. 26, 2004	1, 2	0 to 53	0.500
SGLS - B	Sept. 14-15, 2004	3, 4, 5	52 to 241	0.500
NMLS	Sept. 20, 2004	6, 7, 8	50 to 237	0.500
SGLS - C	Sept. 28-29, 2004	9, 10	0 to 55	1.000
			55 to 240	0.500
HRLS	Oct. 7, 2004	11, 12	22 to 33	0.500

Analysis Notes:

Analyst:	McCain	Date:	03/31/05	Reference:	GJO-HGLP 1.6.3, Rev. 0
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SGLS pre-run and post-run verification spectra were collected in the Amersham verifier (serial number 118) at the beginning and end of each day. Both net count rate and FWHM were compared to verification criteria for gamma activity at 609, 1461, and 2615 keV. The 609-, 1461-, and 2615-keV peaks in all verification spectra were within the acceptance criteria for Gamma 4E. A ¹³⁷Cs peak was detected in most verification spectra, a common occurrence at sites with near-surface contamination. Visual examination of the verification spectra indicated the detector is functioning normally, and the results are accepted.

As noted above, contamination was detected on the sonde during logging operations on September 14, 2004. Radiological surveys conducted on September 15, 2004 confirmed the presence of contamination on wipes used to decontaminate the sonde. Because of radiological survey activities, the post-run verification spectrum was not collected on September 15.

HRLS pre-run and post-run verification spectra were collected in the high rate verifier (serial number 1013). The net count rate for the 662-keV peak was within acceptance criteria.

Log spectra for the SGSLs were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Pre-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G4EJul04.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. The casing configuration was assumed to consist of 10-in. inner-diameter (ID) casing (0.5-in. wall thickness) from ground surface to 55 ft, and 7 5/8-in. ID casing (0.5-in. wall thickness) from the ground surface to 245 ft. A correction factor for 0.5-in. casing thickness was used for most runs. Where log data were collected inside the double casing, a casing correction factor for 1-in. casing thickness was applied. Dead time corrections were applied to the SGSLs data where dead time exceeded 10 percent. Where SGSLs dead time exceeds 40 percent, HRLS data are substituted. No water correction was applied.

Because of the contamination detected on the logging sonde, data collected on September 14 were not used for analysis.

High rate log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations for HRLS spectra were calculated in EXCEL (source file G1CMay04.xls). A correction factor for 0.5-in- thick casing was applied to the HRLS data.

The neutron moisture log is presented as raw count rate vs. depth, and count rates are converted to volumetric percent moisture using the calibration function for an 8-in. ID casing.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, naturally occurring radionuclides (^{40}K , ^{238}U , and ^{232}Th), man-made radionuclides, and neutron moisture. Repeat logs are included for the SGLS, NMLS, and HRLS. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. Combination plots including the neutron moisture data are also provided to facilitate correlation.

An additional plot is provided to show all log results, including data collected when the sonde was contaminated.

Results and Interpretations:

^{137}Cs , man-made ^{238}U (based on the $^{234\text{m}}\text{Pa}$ gamma line at 1,001 keV) and ^{60}Co were detected in this borehole. ^{137}Cs occurs near the ground surface, with a maximum concentration of 131 pCi/g at 1 ft. An interval of high ^{137}Cs concentration occurs between 19 and 55 ft. Within this interval, SGLS dead time exceeds 40% from 23 to 32 ft, and the maximum ^{137}Cs concentration of approximately 85,000 pCi/g appears to occur in two very thin beds at about 29 and 31 ft. Man-made uranium and ^{60}Co occur immediately below the zone of high gamma activity associated with ^{137}Cs . The maximum concentration of man-made ^{238}U is 201 pCi/g at 33 ft, decreasing to about 10 pCi/g at 40 ft. This decrease in concentration occurs immediately below the zone of high ^{137}Cs , and it is likely that ^{238}U occurs in this zone as well, but is masked by the high activity associated with ^{137}Cs . ^{60}Co was detected continuously from 33 to 38 ft and intermittently from 39 to 52 ft. Maximum concentration is 1.4 pCi/g at 33 ft. As with man-made ^{238}U , it is likely that ^{60}Co also occurs within the high ^{137}Cs interval.

SGLS log run 3 on September 14, 2004 indicates ^{137}Cs concentrations between 1.3 and 3 pCi/g, with an average of about 1.8 pCi/g throughout the interval between 66 and 241 ft (see the composite plot of all log data). This is interpreted to be the result of contamination on the sonde and/or the inside of the casing. SGLS log runs 9 and 10 were conducted on September 28 and 29, after the sonde had been cleaned and the borehole had been swabbed with no contamination detected on the swab. These log runs indicate isolated intervals of ^{137}Cs , generally at or near the MDL of 0.2 to 0.3 pCi/g. Below 55 ft, traces of ^{137}Cs were detected from 56 to 58 ft, 85 to 86 ft, 156 to 157 ft, and 231 to 233 ft. A concentration of about 3.5 pCi/g was detected at 240.5 ft. The final man-made radionuclide plot that is considered most representative of subsurface conditions uses SGLS data from runs 1, 9 and 10, and HRLS data from run 11.

Repeat logs for the SGLS demonstrate good repeatability for the natural radionuclides (1461, 1764, and 2614 keV). Repeat logs for the HRLS demonstrate good repeatability for ^{137}Cs (662 keV).

Neutron moisture data were collected in the single cased interval below 55 ft. Moisture values ranged between 2 and 12 percent by volume, with many relatively thin beds of higher moisture content between 135 and 233 ft. Repeat logs for the NMLS demonstrate good repeatability.

Although much of the ^{137}Cs detected below 55 ft in borehole C4176 can be attributed to sonde contamination from borehole C4671, the possibility of internal contamination in borehole C4176 cannot be entirely ruled out, even though borehole swabs failed to detect contamination. As noted above, ^{137}Cs was detected in trace amounts at several intervals below 55 ft after contamination had been removed from the sonde. While this has been plotted under the assumption that it is distributed in the formation, the possibility exists that it may represent contamination on the inside of the casing.

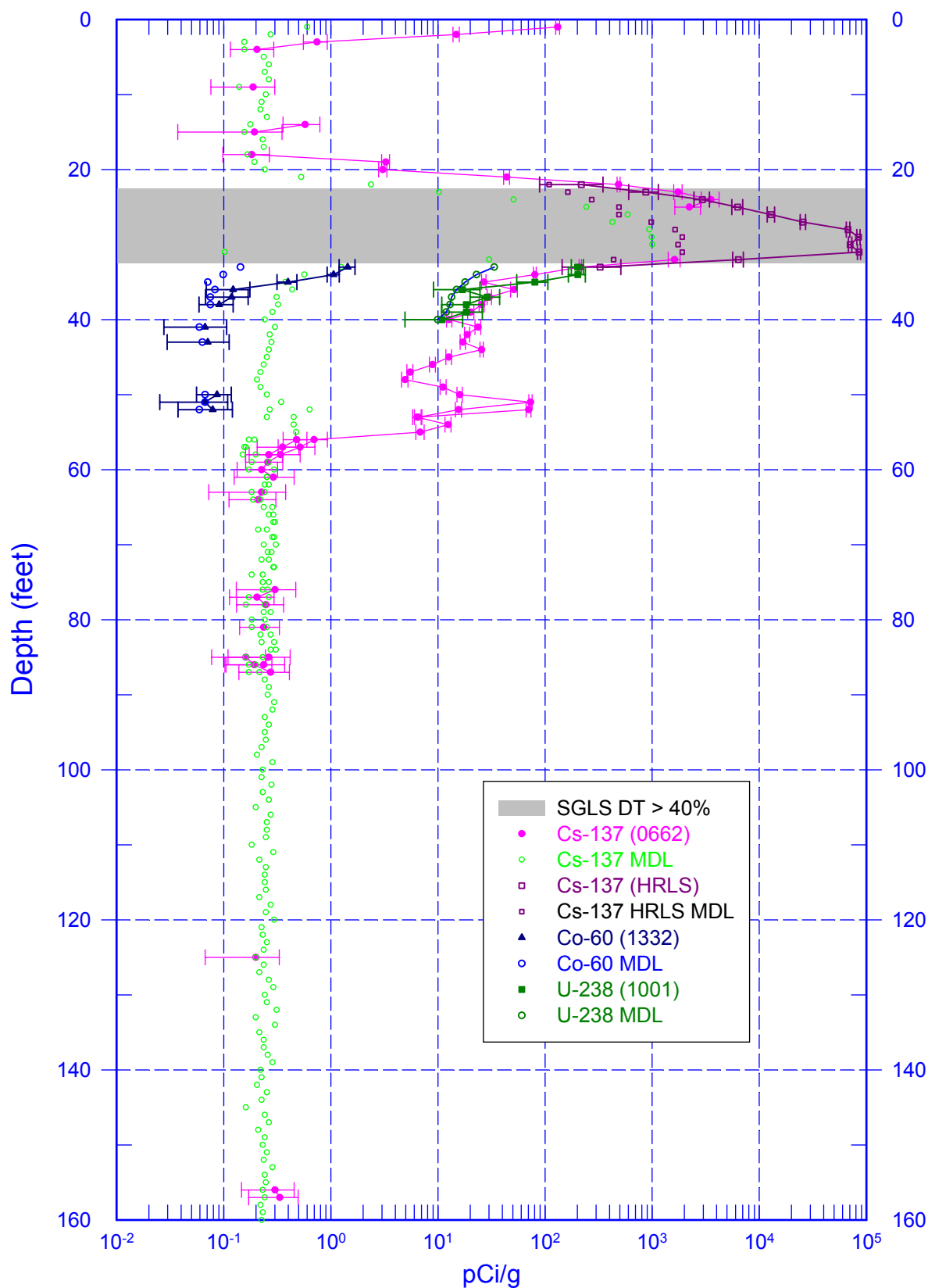
¹ GWL – groundwater level

² TOC – top of casing

³ N/A – not applicable

C4176

Man-Made Radionuclides

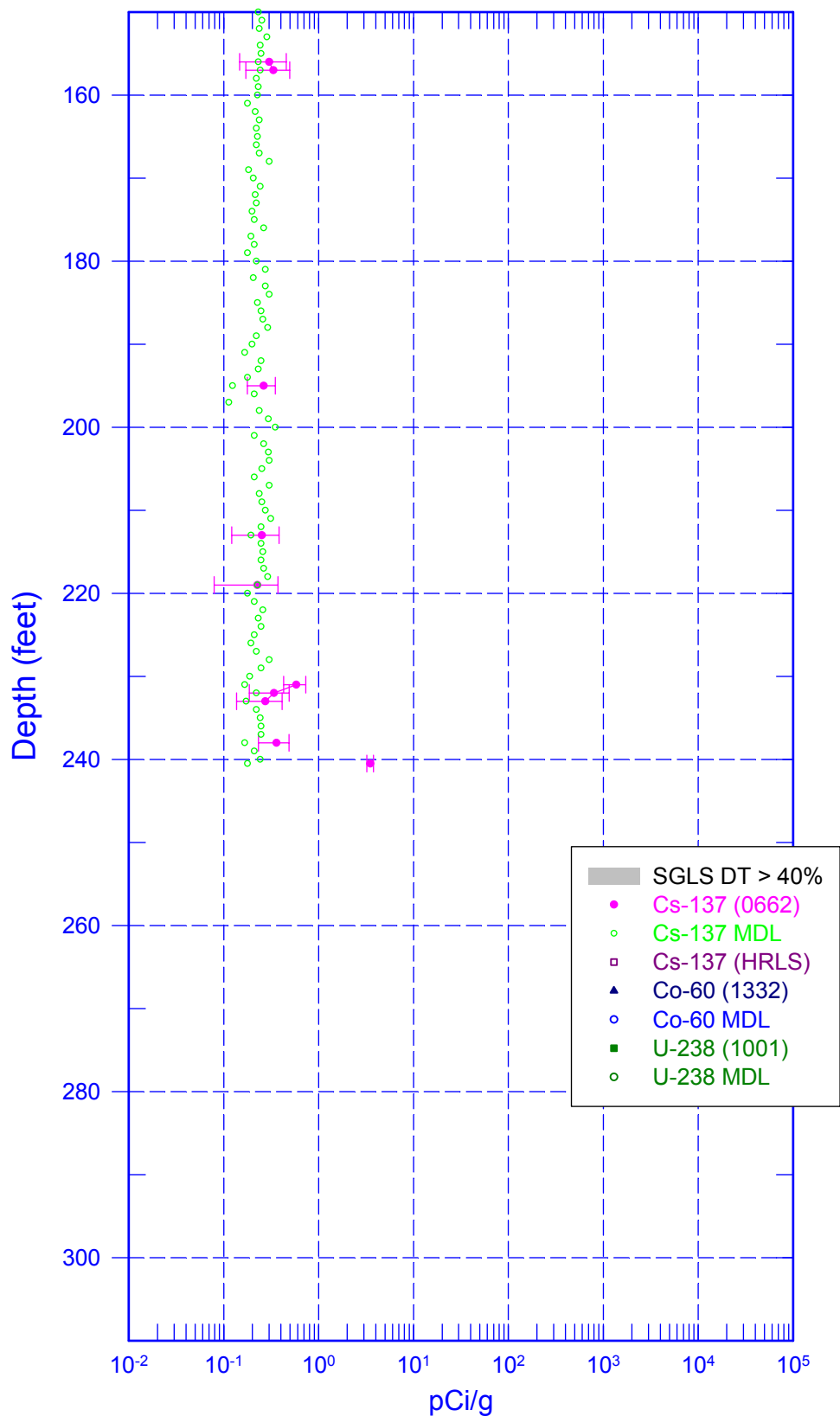


Zero Reference = Ground Surface

Last Log Date - 10/07/04 (HRLS)

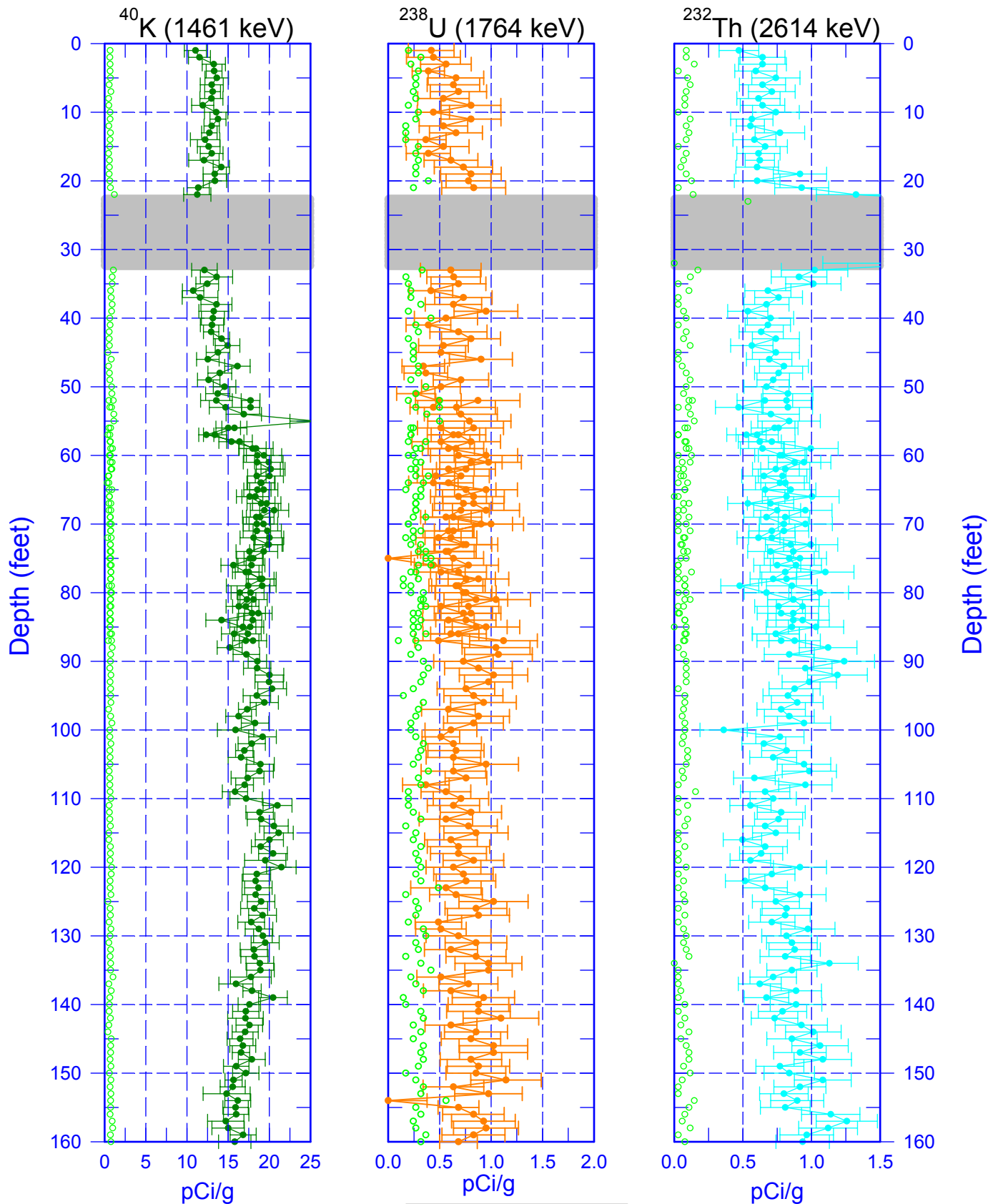
C4176

Man-Made Radionuclides



C4176

Natural Gamma Logs



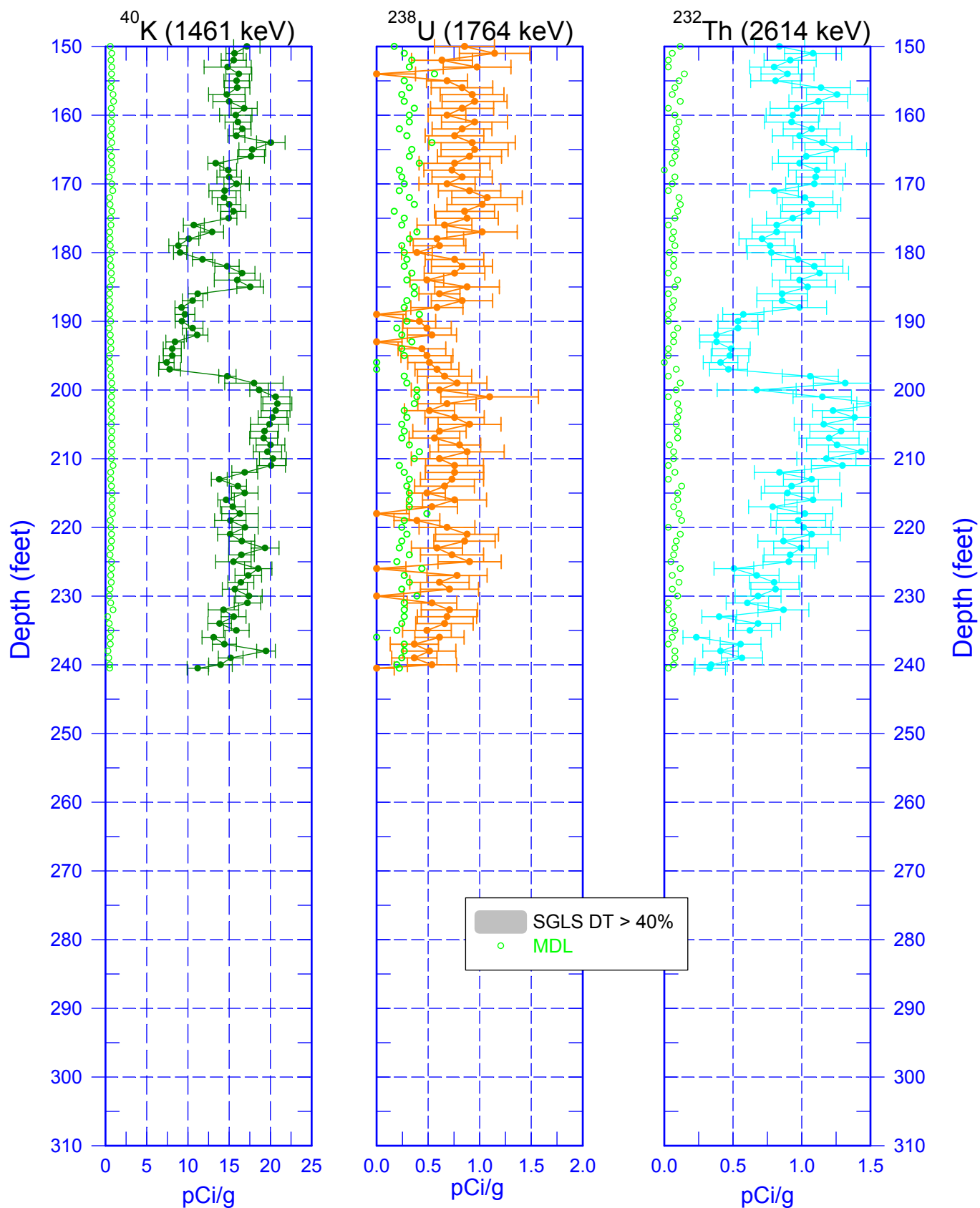
Zero Reference = Ground Surface



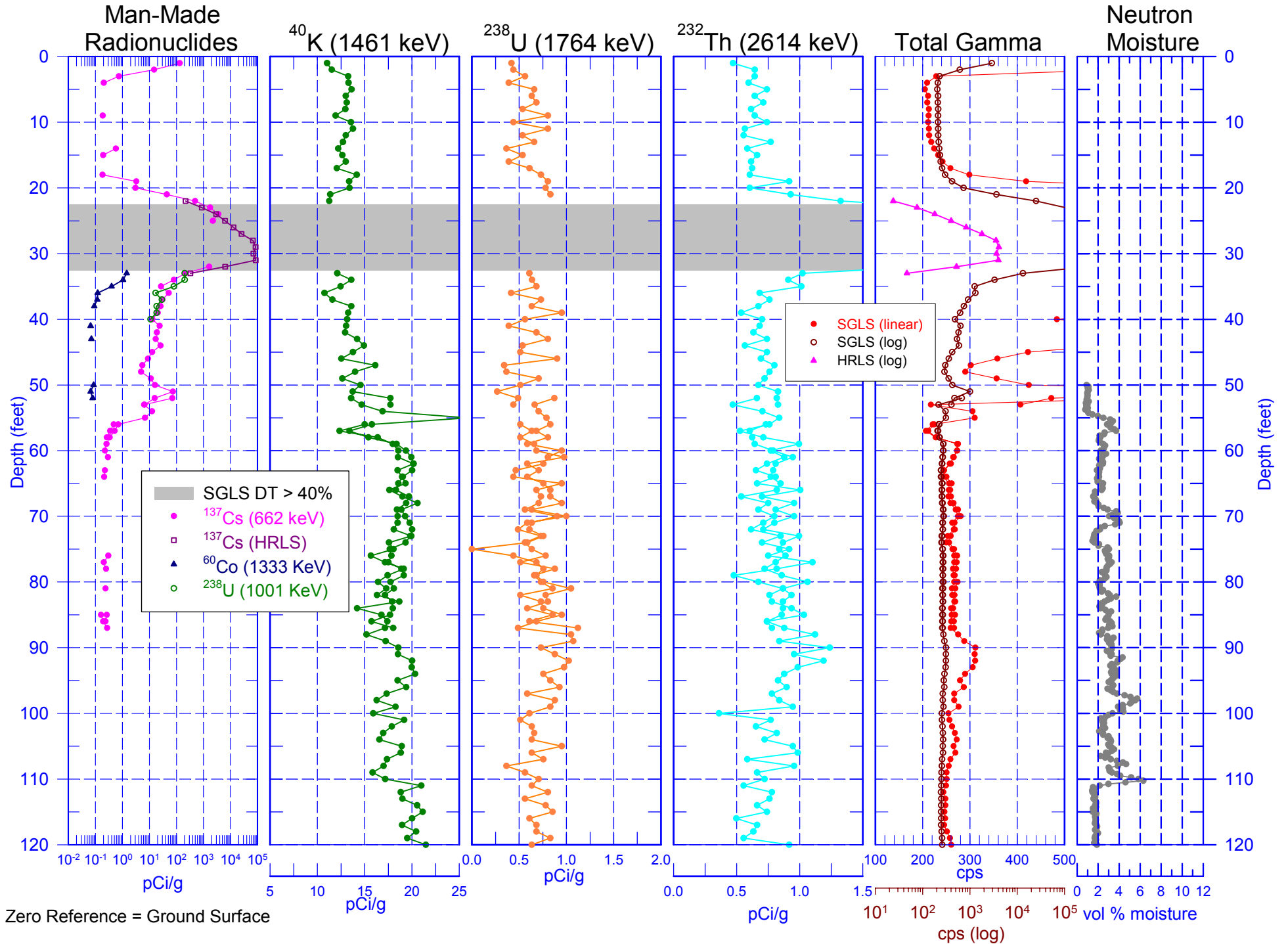
Last Log Date - 09/29/04

C4176

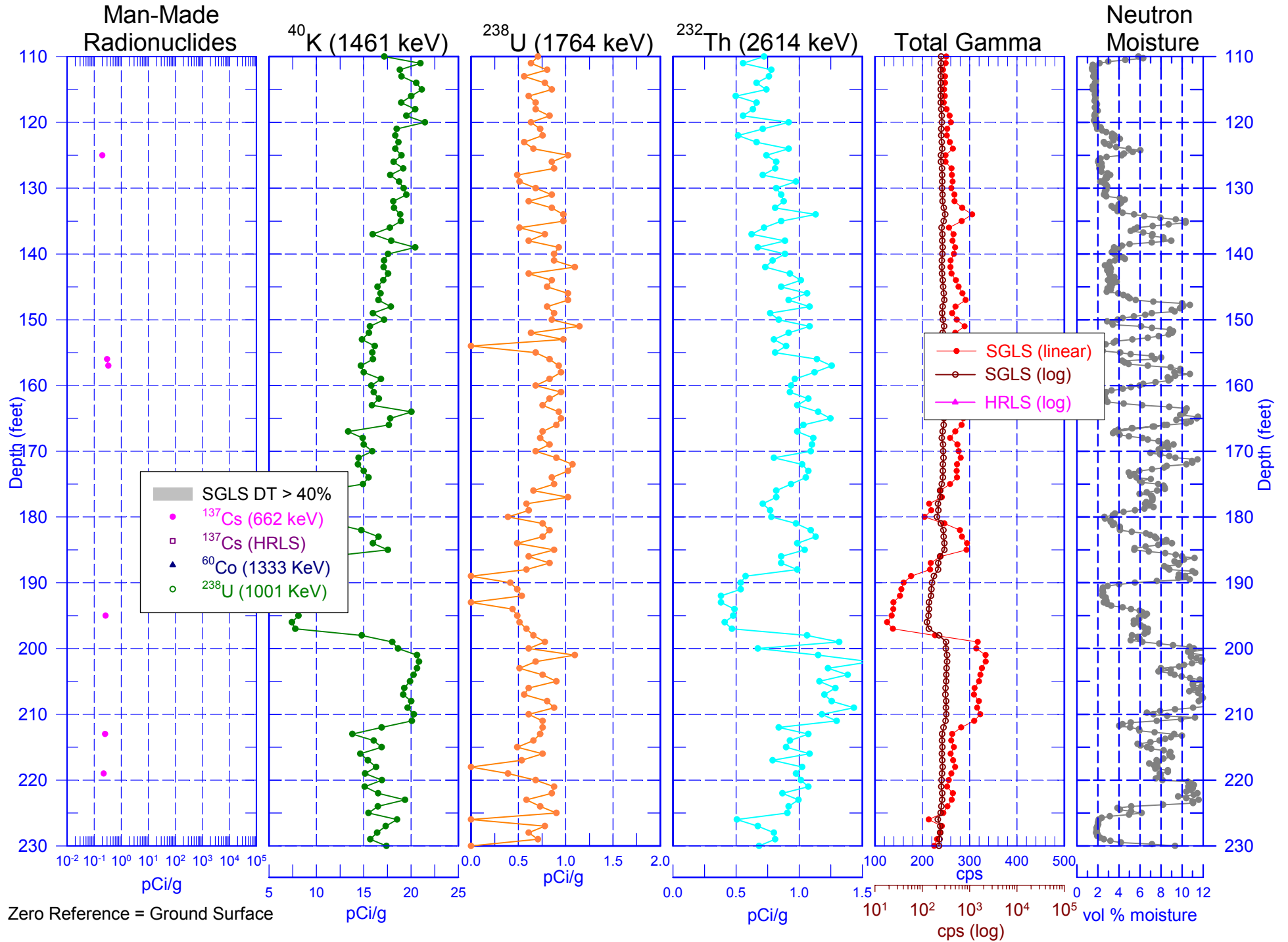
Natural Gamma Logs



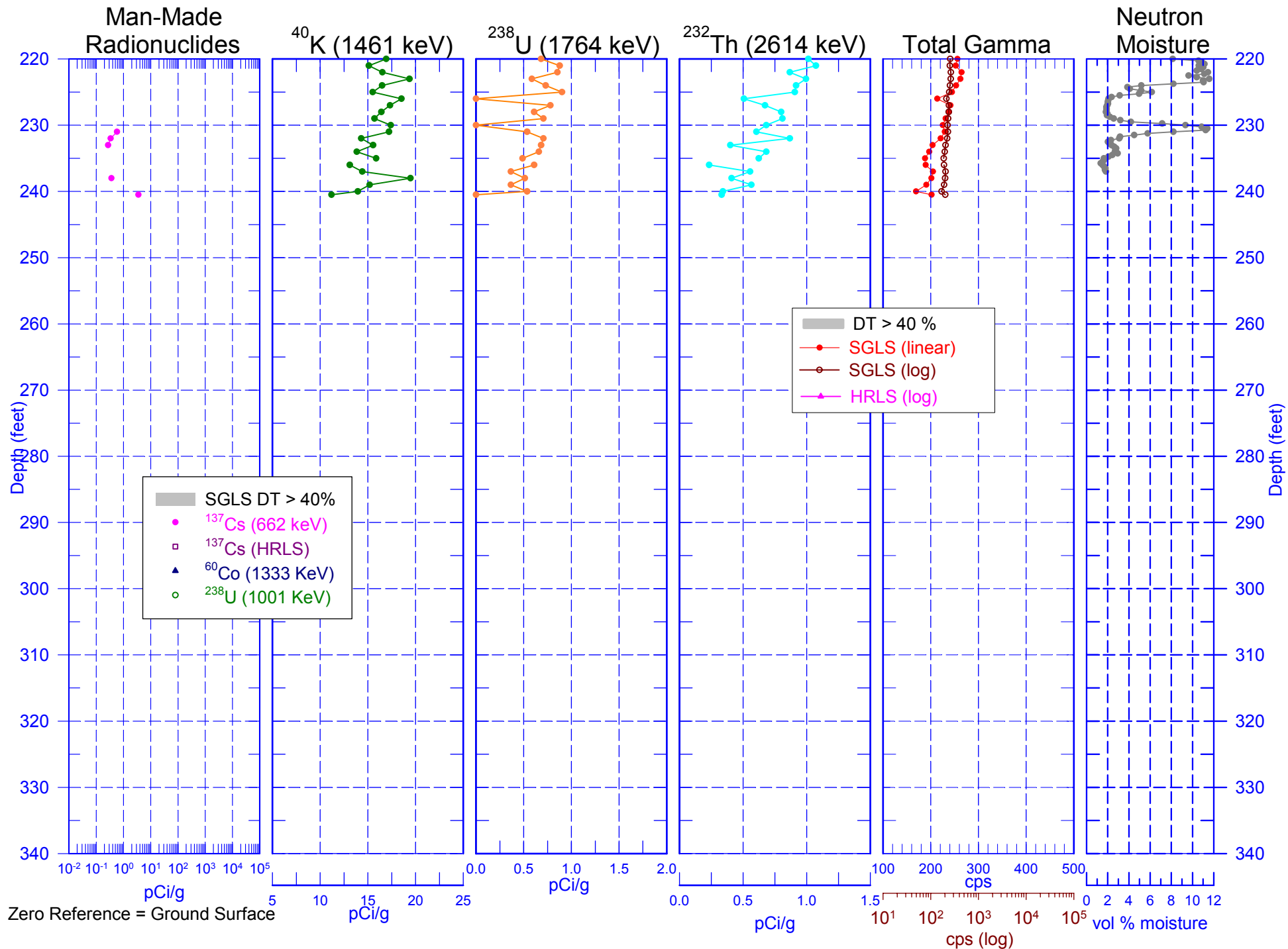
C4176 Combination Plot



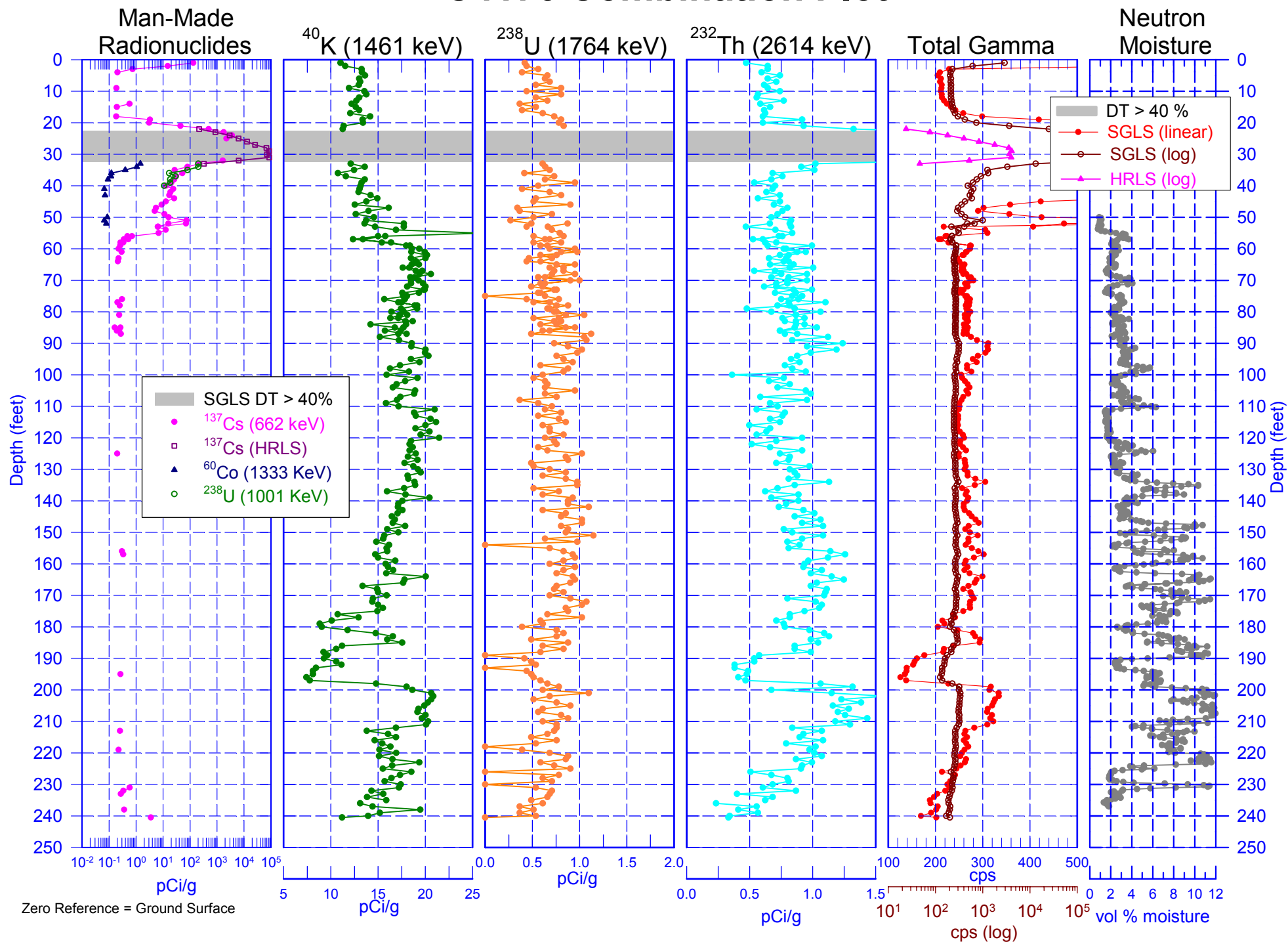
C4176 Combination Plot



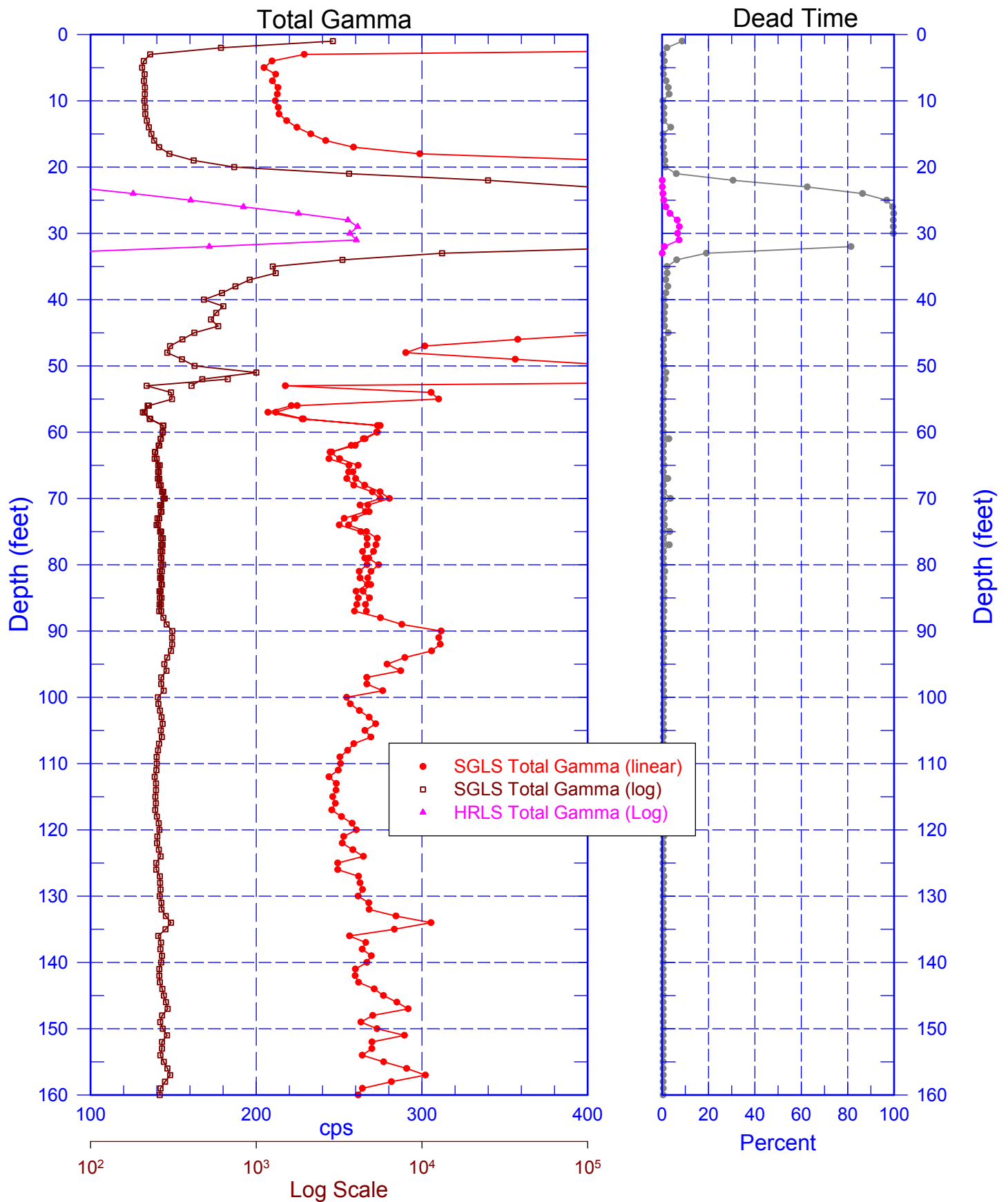
C4176 Combination Plot



C4176 Combination Plot



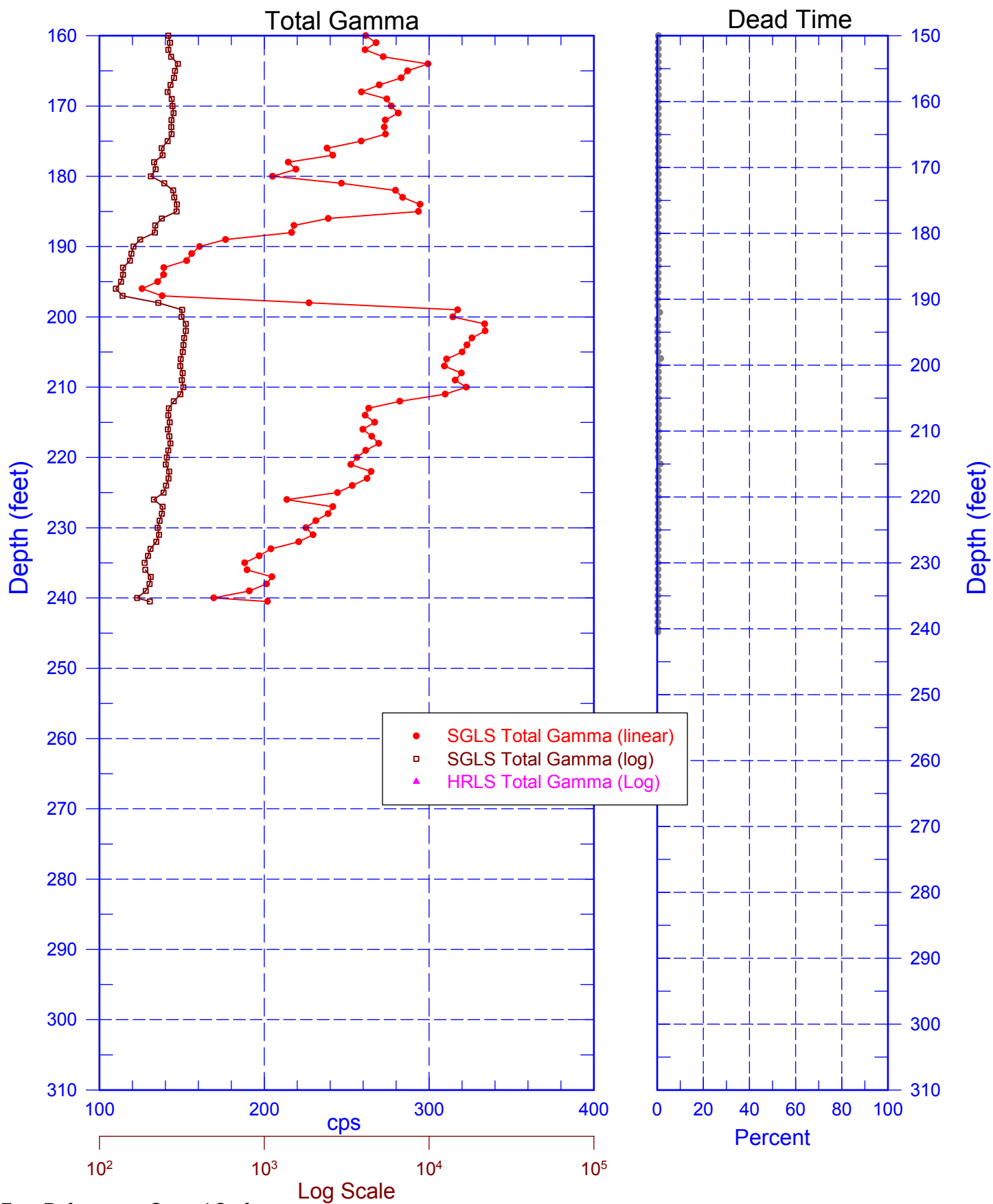
Total Gamma & Dead Time



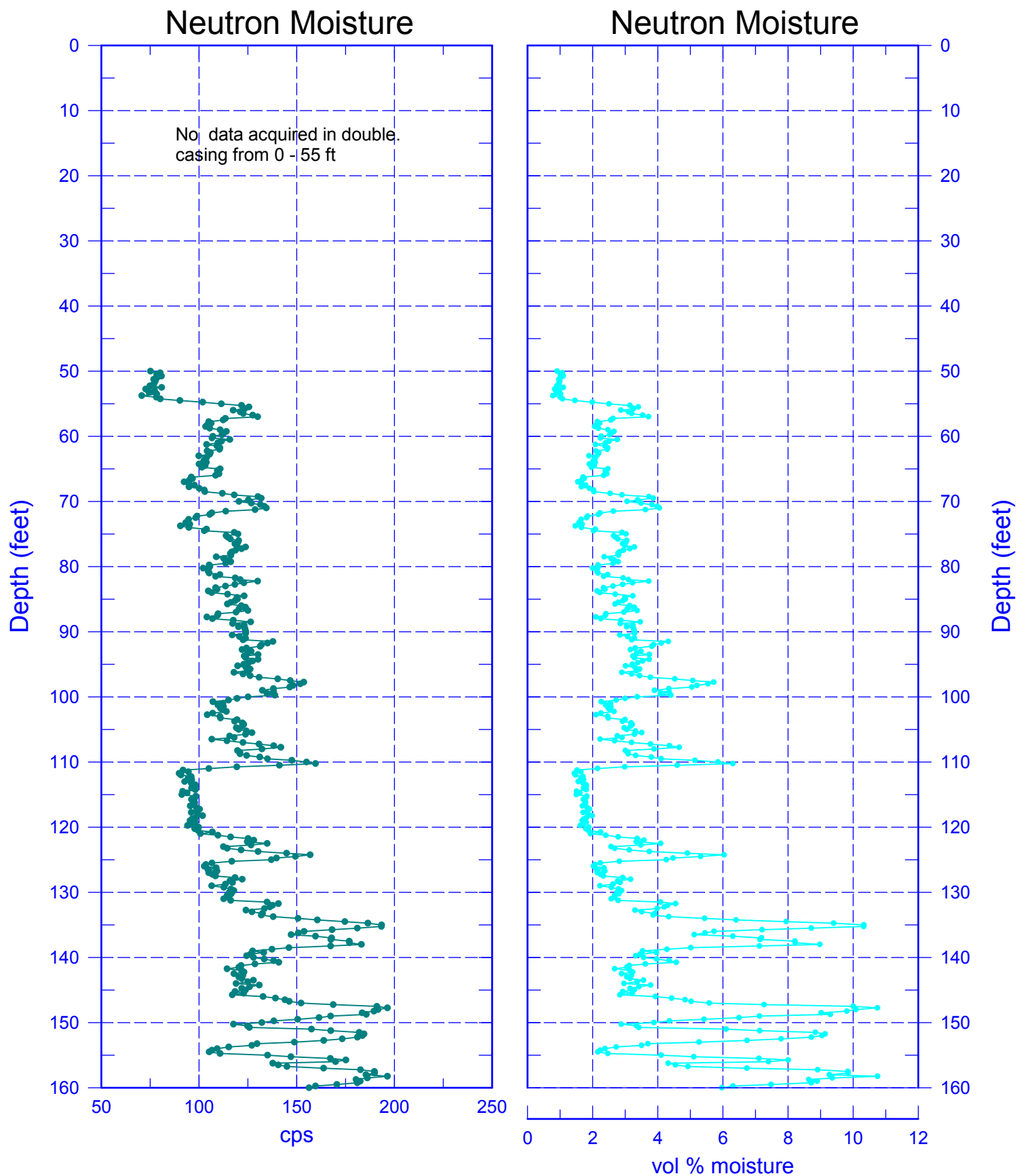
Zero Reference = Ground Surface

C4176

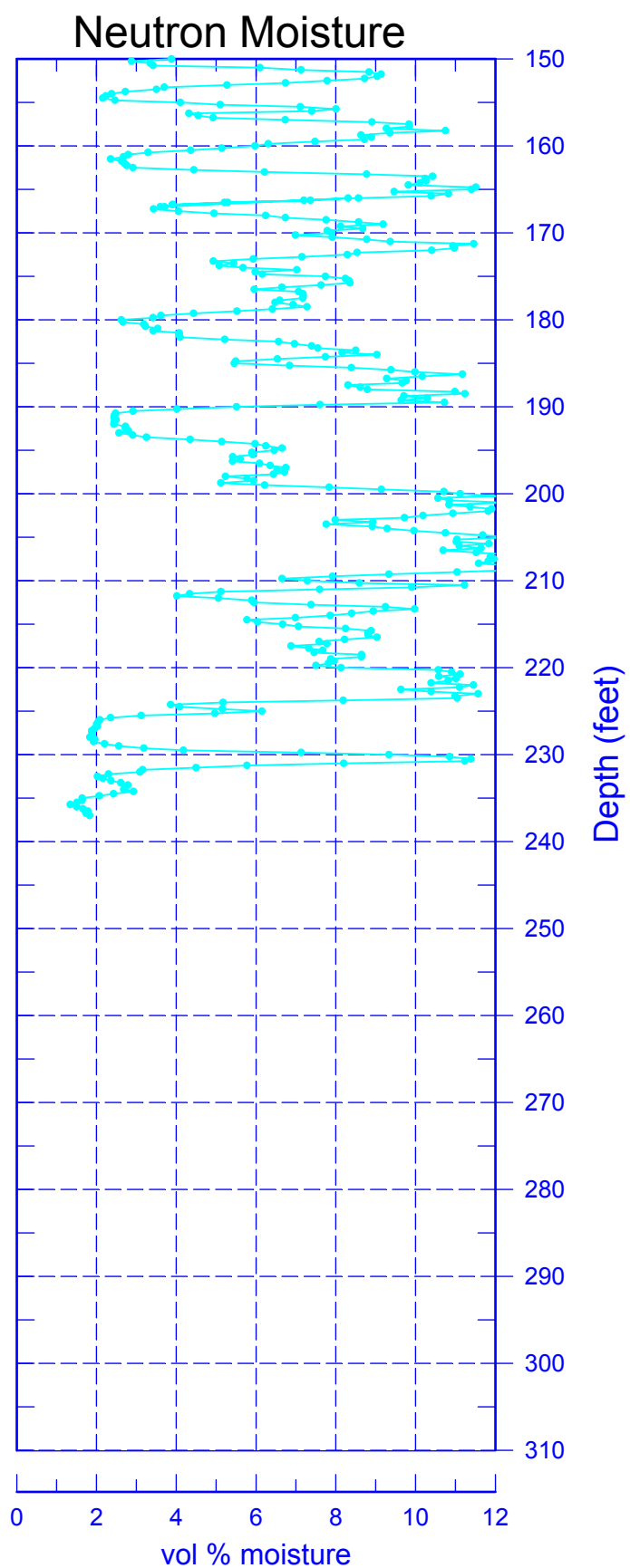
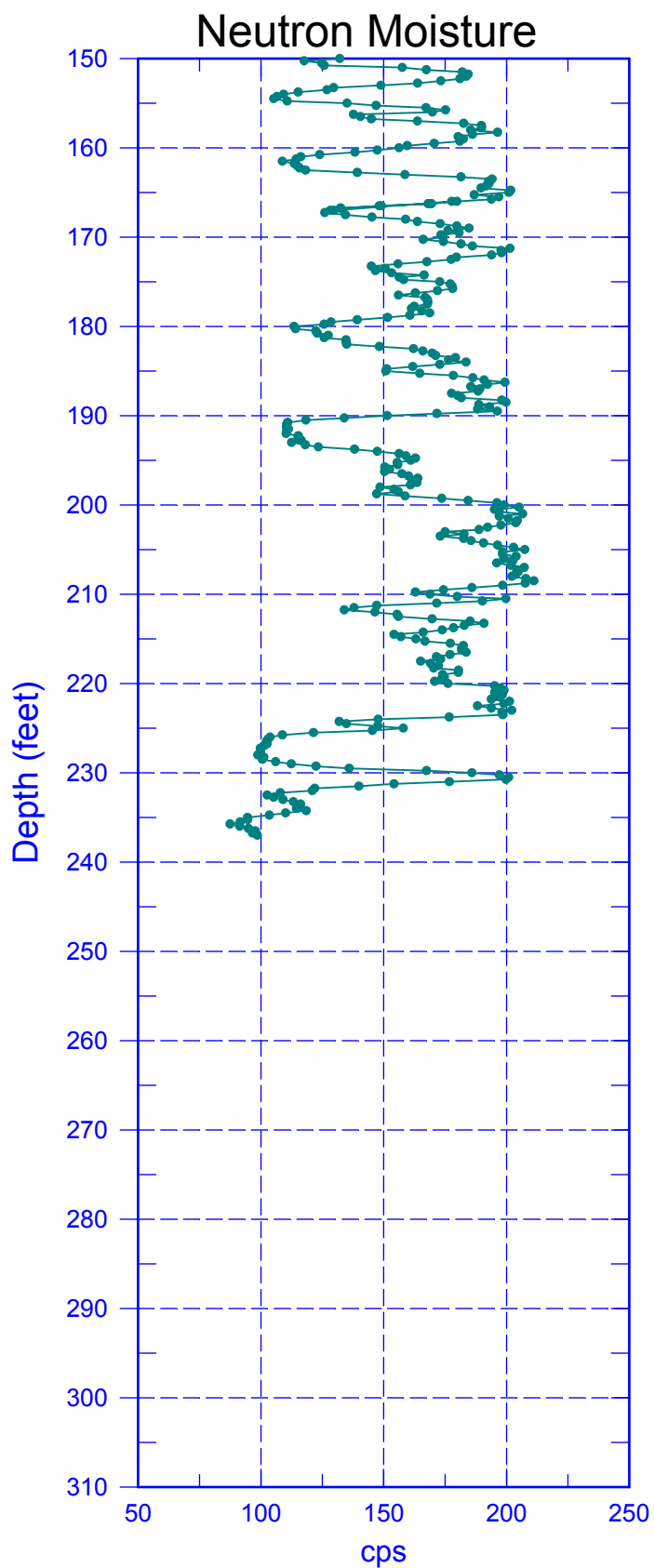
Total Gamma & Dead Time



C4176

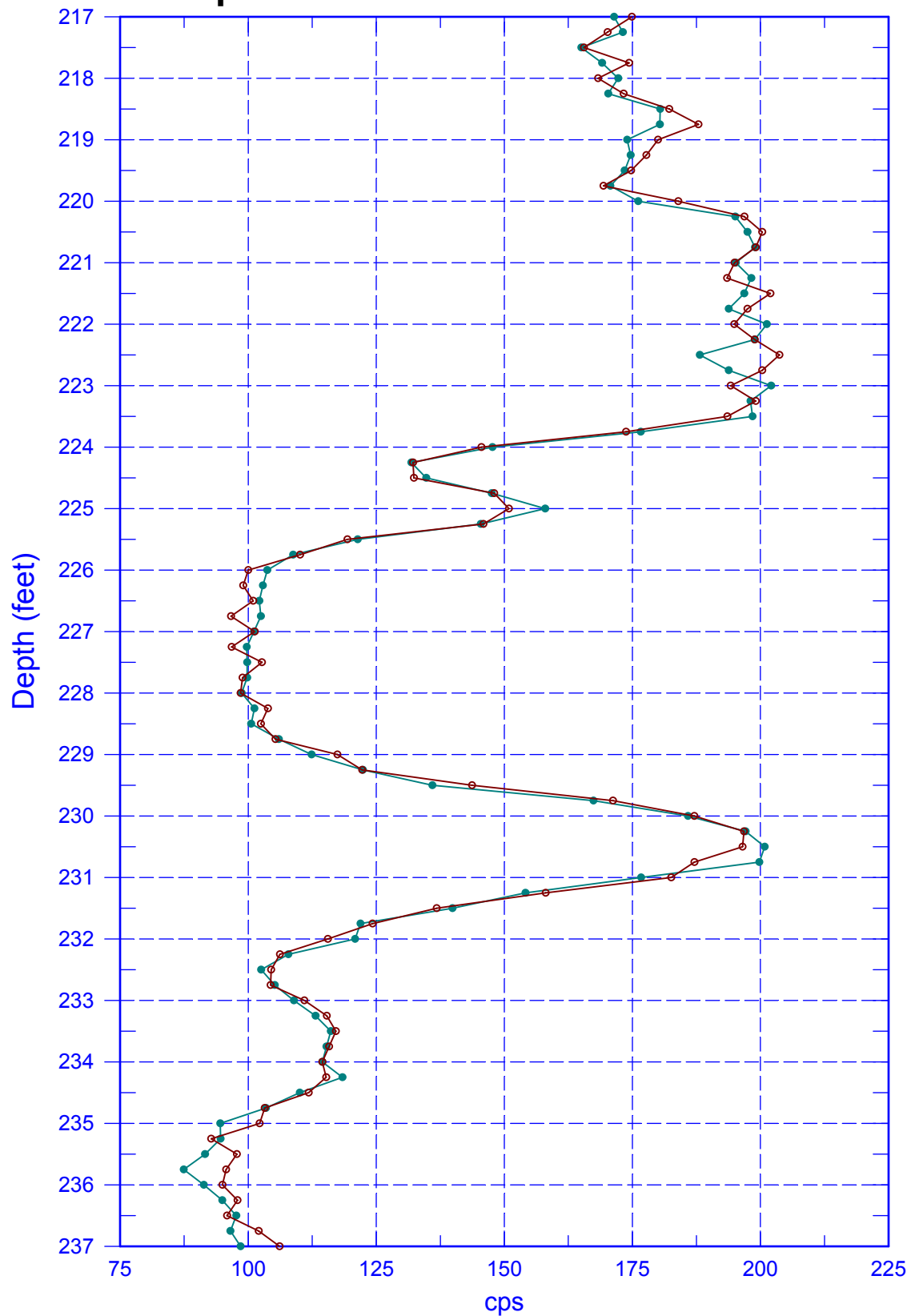


C4176



C4176

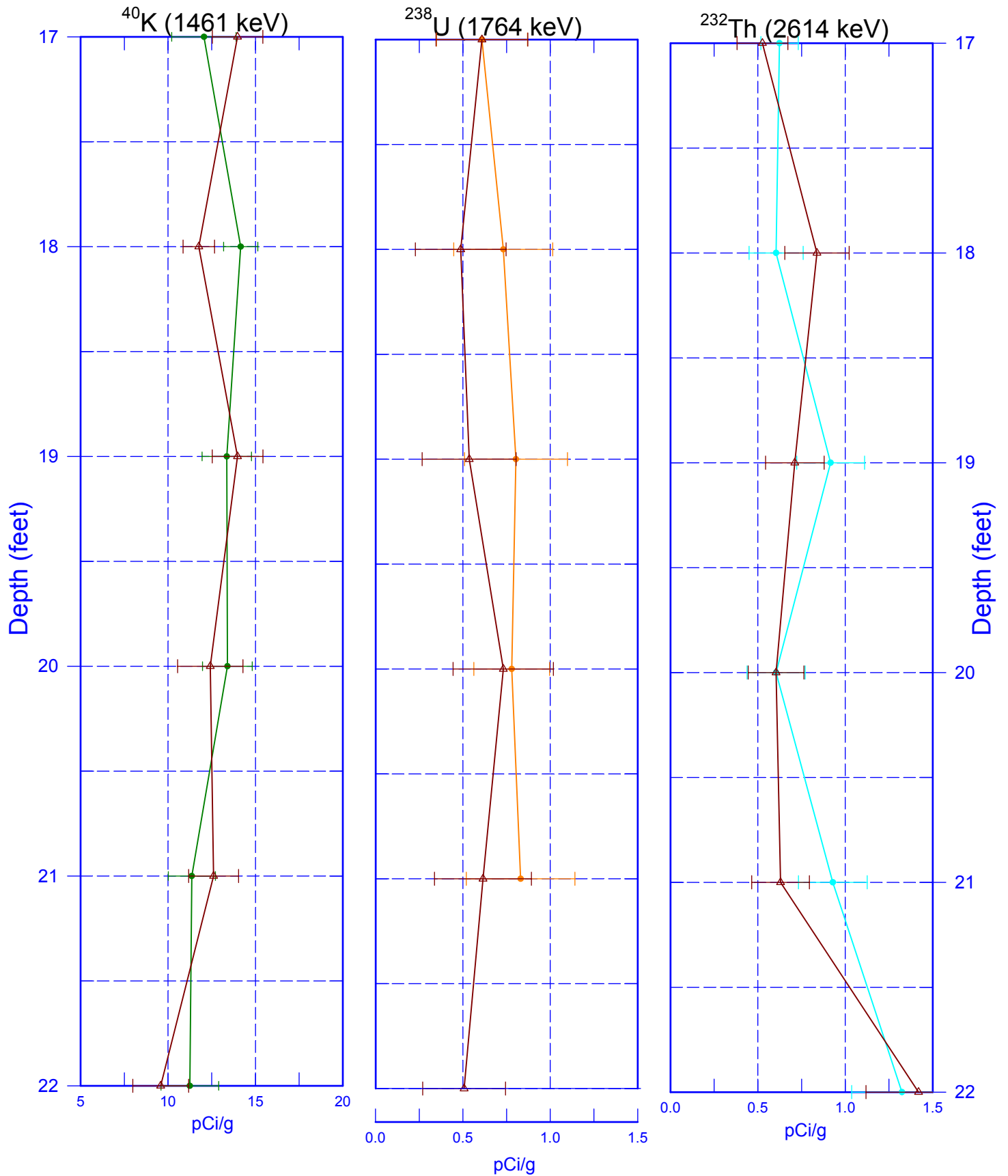
Repeat Section of Neutron Moisture



Zero Reference = Ground Surface

C4176

Repeat Section of Natural Gamma Logs

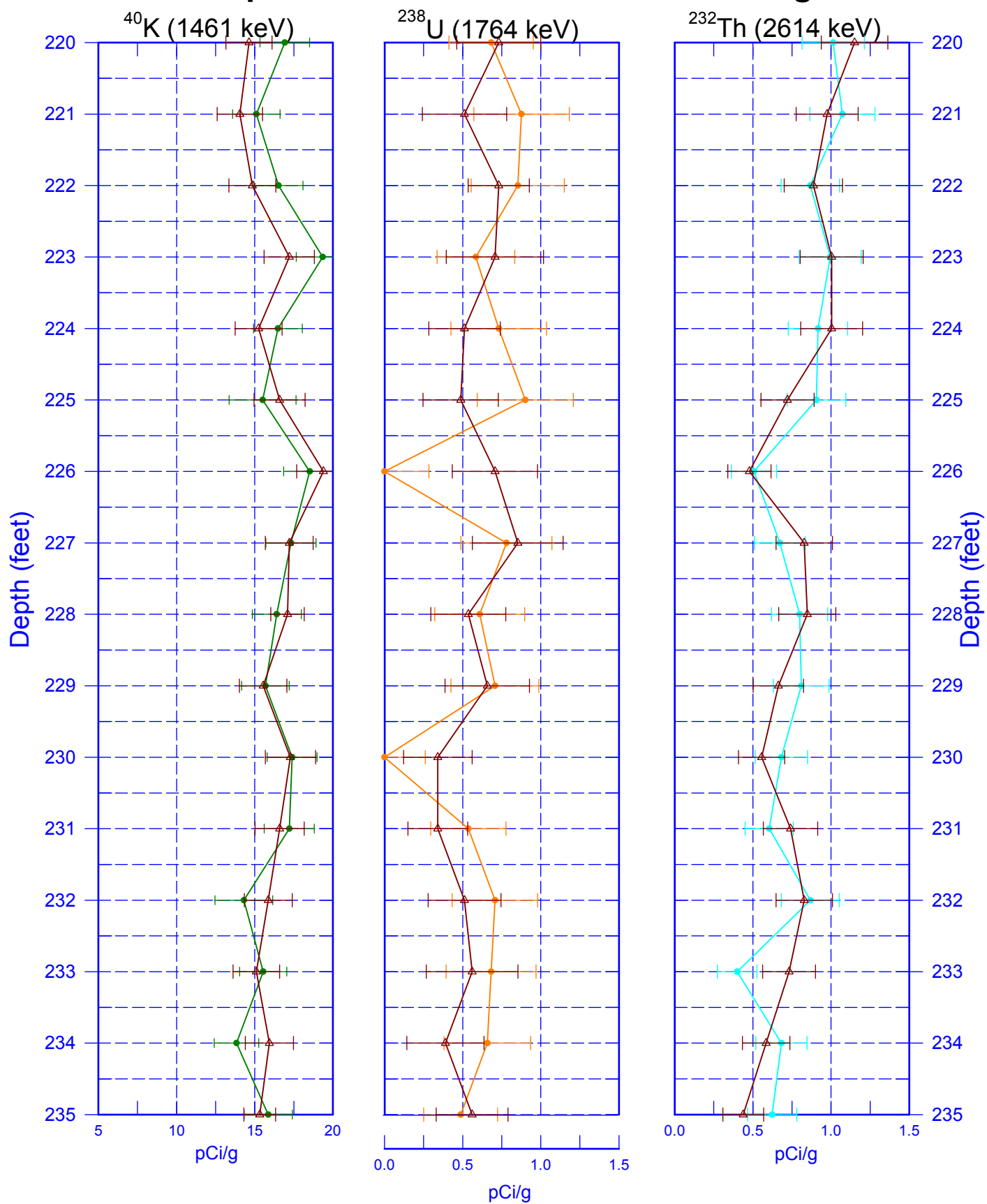


Zero Reference = Ground Surface

Last Log Date - 09/15/04

C4176

Repeat Section of Natural Gamma Logs

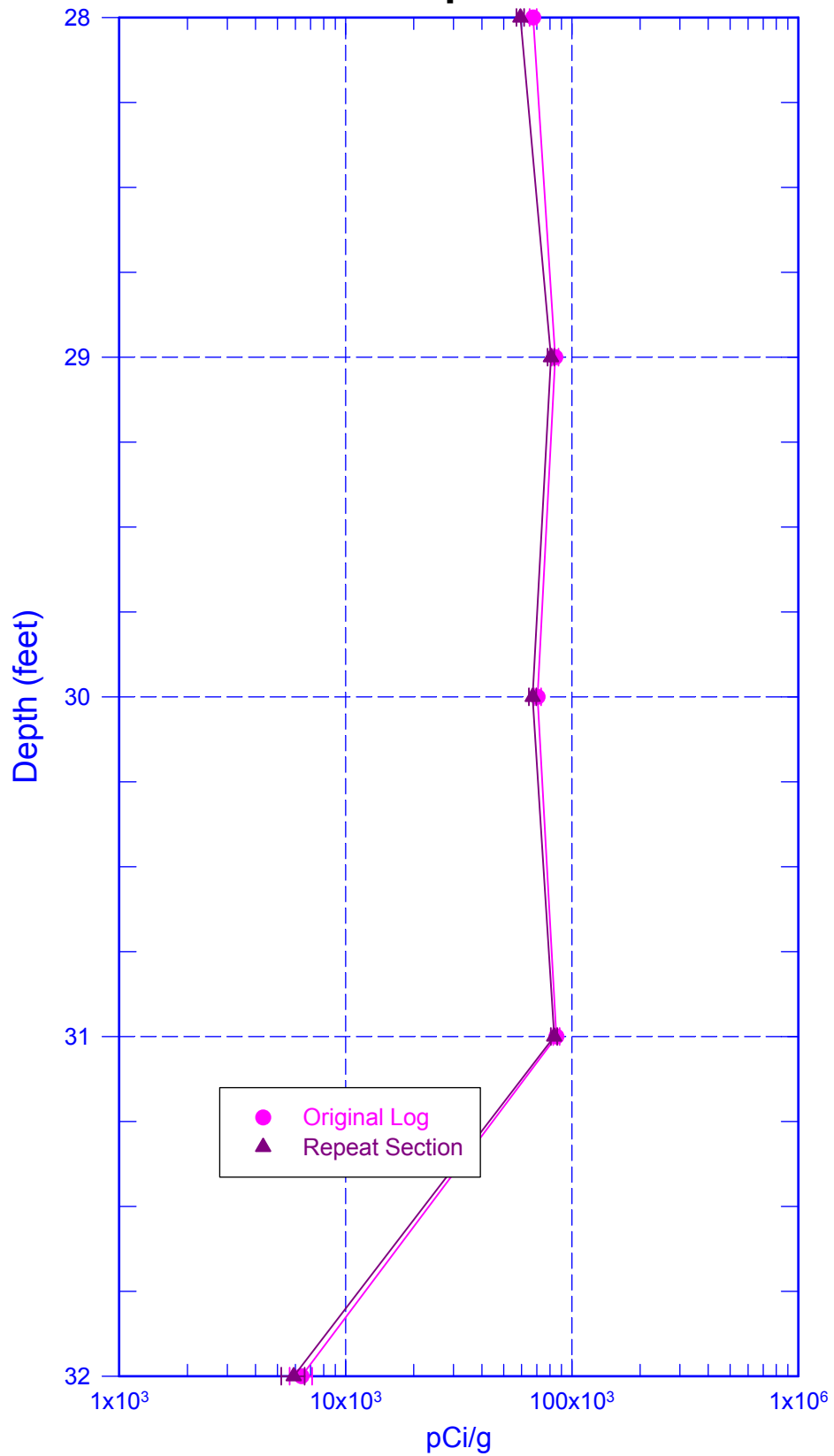


Zero Reference = Ground Surface

Last Log Date - 09/15/04

C4176

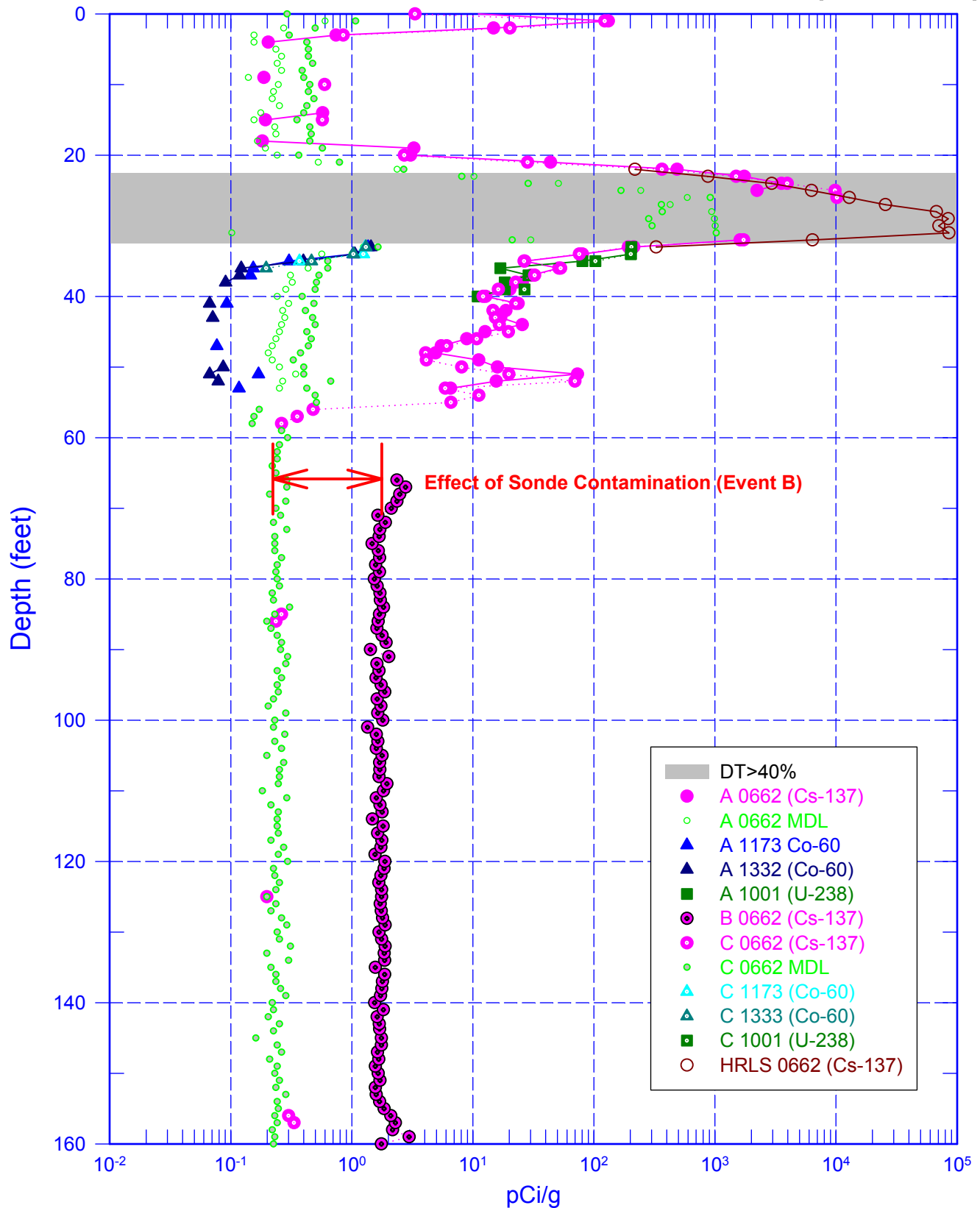
HRLS Repeat Section



Zero Reference = Ground Surface

C4176

Composite of Man-Made Radionuclides (All Data)



Evaluation of Sonde Contamination Incident in Boreholes C4176 and C4671

Introduction

On September 15, 2004, radioactive contamination was detected on the spectral gamma logging system (SGLS) designated Gamma 4E while logging in borehole C4176, near the 216-S-20 Crib. Evaluation of the log data showed the sonde was contaminated with residual ^{137}Cs , and data collected in borehole C4176 between 241 and 66 ft on September 14, 2004 are suspect. This incident prompted a thorough investigation of recent log data to determine how the sonde became contaminated and to assess any effect this contamination may have had on other borehole logs. This document summarizes findings and provides recommendations to avoid future occurrences.

Evaluation of Log Data

Log data for borehole C4176 are shown in Figure 1. For discussion purposes, the logging activities are broken down into three separate events, with individual runs within each event identified by letters. All log runs were conducted with SGLS Gamma 4E.

Date	Event	Depth Interval (ft)
8/26/04	Run 1	53 - 0
9/14/04	Run 2a	241 - 66
9/15/04	Run 2b	87 - 52
9/28/04	Run 3a	0 - 235
9/29/04	Run 3b	240.4 - 220

Borehole C4176 was drilled with a cable tool rig in two stages, using telescoping casing to seal off contamination in the upper vadose zone. In the first stage, 10-3/4 in. OD casing was set at 55 ft. The borehole interval from 0 to 53 ft was logged on August 26, 2004 (Run 1). The SGLS detected high gamma activity from 20 to 35 ft. ^{137}Cs was detected at the ground surface and from 19 to 53 ft. Near the ground surface, 131 pCi/g was detected at 1-ft depth. The maximum concentration of 3,540 pCi/g was detected at 24 ft. An additional peak was observed at 51 ft, with a maximum concentration of 73 pCi/g. ^{60}Co was detected from 33 to 38 ft, with a maximum concentration of 1.4 pCi/g at 33 ft. Lesser amounts of ^{60}Co were detected at 41 and 43 ft and from 50 to 52 ft. $^{234\text{m}}\text{Pa}$ (an indicator of anthropogenic ^{238}U) was detected from 33 to 40 ft, with a maximum concentration of 201 pCi/g at 33 and 34 ft. It is likely that both ^{60}Co and ^{238}U also exist with the high ^{137}Cs interval from 20 to 33 ft, but they are not detected because of the intense gamma activity associated with ^{137}Cs . Fecht et al. (1977) reported Pu, Sr, ^{137}Cs , ^{60}Co , and U as potential contaminants at the 216-S-20 Crib.

^{137}Cs was also detected in both the pre-run and post-run verification spectra. This was attributed to “shine” from surface contamination. This is a relatively common occurrence and the presence of a 662-keV peak from ^{137}Cs in the verification spectra was not considered unusual, especially because the log showed relatively high values close to the ground surface.

An 8-5/8 in. OD casing was used to advance the borehole from 55- to 245-ft depth. On September 14, 2004, the hole was logged inside the 8-5/8 in. casing (Run 2a). Because the borehole was considered “low risk,” no attempt was made to swab the casing prior to logging. ^{137}Cs was again detected in the pre-run verification spectra, but this was not considered unusual because the counts were comparable to those observed previously (3.72 cps, compared to 3.99 cps). The sonde was lowered to the bottom of the hole at 241 ft and logging proceeded upward to 66 ft. Significant ^{137}Cs was noted at the bottom of the hole and in all subsequent log spectra collected on that day, as well as in the post-run verification spectra (2.6 cps). A well-defined peak was present at 662 keV in all spectra, and the net count rate for the 662-keV peak varied from 2.5 to 7.1 cps, with a mean value of 3.4 cps. This is equivalent to a persistent apparent ^{137}Cs concentration on the order of 1.3 to 3.8 pCi/g and is consistent with the net count rates of 3.7 and 2.6 cps observed in the pre-run and post-run verification spectra.

During the logging operation, the logging engineer wiped the cable as it was withdrawn from the borehole. After approximately 60 ft of logging (sonde at about 180 ft in depth), the logging engineer was replaced. The sonde was withdrawn from the hole at the end of the day and a post-run verification spectrum was collected. ^{137}Cs was also noted in the post-run spectrum. The following day (September 15), a pre-run verification spectrum was collected and the sonde was lowered to a depth of 87 ft, from where logging proceeded upward to 52 ft (Run 2b). The interval from 87 to 67 ft was labeled as a repeat section because it had been logged the previous day. While logging operations were underway, Radiation Control Technicians (RCTs) surveyed the wipes used to clean the cable, sonde, and centralizer from the previous day, and contamination was detected. The gloves of both logging engineers were also contaminated. The sonde was left inside the borehole while a complete radiological survey of the logging system was performed. When the sonde was removed from the borehole, contamination was detected on the centralizer. A post-run verification spectrum was not collected on this day because of the delay in removing the sonde from the borehole. Evaluation of log data for September 15 (Run 2b) does not show evidence of sonde contamination. Apparent ^{137}Cs concentrations in the repeat interval are at or near the MDL of approximately 0.2 to 0.3 pCi/g. A borehole swab in borehole C4176 after the logging events did not detect any evidence of contamination.

From September 28 to 29, 2004, borehole C4176 was re-logged after it had been determined that log data collected on September 14 were affected by contamination on the sonde. Run 3a on September 28 extended from ground surface to 235 ft. After logging was completed, the cable was checked for contamination as the sonde was withdrawn from the borehole, and no contamination was detected. Run 3b was conducted on September 29. In this run, the sonde was allowed to touch bottom and the borehole was logged from 240.4 to 220 ft. Total depth of the borehole was 240.4 ft on September 29, compared to 241.0 ft on September 14. Pre- and post run verification spectra collected on September 28 and 29 showed only traces of ^{137}Cs . A background spectrum collected prior to logging on September 29 also showed only minor ^{137}Cs activity, which can be attributed to "shine." ^{137}Cs was detected at the bottom of the borehole, at an apparent concentration of 3.5 pCi/g. This is very close to the value observed at the bottom of the borehole on September 14. ^{137}Cs was also detected from 231 to 233 ft, with a maximum concentration of about 0.6 pCi/g, and at 156 to 157 ft, with a maximum concentration of about 0.33 pCi/g. The peaks at 156 and 157 ft correspond to an increase in ^{137}Cs observed in the September 14 log.

Probable Source of Contamination

When the sonde was examined after logging on September 15, sandy material on the centralizer was found to be contaminated. This material most likely originated from borehole C4176, and it is likely that contaminated material was encountered near the bottom of the borehole. Material lost from the drive barrel during sampling may have contributed to low levels of internal contamination in borehole C4176. Both the "contaminated" SGLS log on September 14 and the repeat log on September 28 consistently detected ^{137}Cs at the bottom of the borehole and from 156 to 157 ft.

Prior to the drilling of borehole C4176, Gamma 4E had most recently been used to log borehole C4671 on September 1, 2004. This was a direct push tube (DPT) installed at the 216-A-4 Crib. It was installed approximately 4 ft away from borehole C4560, which had been suspended after unanticipated levels of subsurface contamination were encountered. Borehole C4671 was intended to investigate this contamination. It consisted of a 6-in.-diameter heavy wall steel casing with a solid tip driven into the ground. Because of the plug in the end of the casing, it was considered a "low risk" borehole even though it was known to penetrate significant contamination. ^{137}Cs concentrations in excess of 236 million pCi/g were measured in this borehole. This borehole was also logged with the HRLS and the passive neutron logging system. Further investigation showed that the passive neutron sonde and the external shield for the high rate logging system were also contaminated. A borehole swab in borehole C4671 also indicated contamination.

From this information it is concluded that the initial source of the sonde contamination was borehole C4671. However, the possibility of internal contamination in borehole C4176 remains probable,

even though a borehole swab after logging operations failed to detect any contamination. Between logging events on September 14 and September 15, the cable, sonde, and centralizer were cleaned. The wipes and other material from this operation were bagged. When they were checked on September 15, contamination was detected. Comparison of log data from September 15 (Run 2b) and September 14 (Run 2a) clearly shows that most, if not all, of the contamination on the sonde was removed by the cleaning. When the sonde was removed from the borehole on September 15, fine-grained material had accumulated on the centralizer and this material was found to be contaminated. Because the cleaning would have removed all visible material, it is almost certain that this material originated from borehole C4176. This contamination is most likely related to material lost from drive barrels or samplers when the borehole was at or near total depth.

Evaluation of Verification Data

Investigation of the contamination incident led to evaluation of previous verification spectra. Table 1 summarizes borehole intervals logged with SGLS Gamma 4E between August 26 and September 29, 2004. This time period extends from the first log of borehole C4176 through the final logging operations performed to replace suspect data, and lists all logs within that period. The radioactive contamination is known to be ^{137}Cs ; therefore, all verification spectra have been reprocessed to “force” a region of interest for the 661.62-keV gamma line from ^{137}Cs . In addition, the net count rate for the 1460.83-keV gamma line from ^{40}K (typically the most prominent peak in the verification spectrum) is shown, and the ratio between net count rate for the 662-keV peak vs. net count rate for the 1461-keV peak is also shown.

The presence of a 662-keV peak in verification spectra is not uncommon, and net count rates of 1 to 4 cps can be attributed to “shine” or ambient activity from surface contamination or other sources unrelated to the logging activity. The exceptions are verification spectra collected on September 1, 2004, at borehole C4671. Net count rates of about 34 cps were observed for the 662-keV gamma line in both the pre- and post-run verification spectra collected that day. Although this is substantially greater than normal, the fact that it appeared in the pre-run verification spectra indicated that there were unusually high ambient levels of ^{137}Cs . Because there appeared to be a slight decrease from the pre-run to the post run, the observed ^{137}Cs peak was attributed to “shine.” However, it is known that the overall efficiency of the SGLS detector tends to decrease slightly over the course of a day. Therefore, the net counts at 662 keV were “normalized” relative to net counts for the ^{40}K peak at 1461 keV, which should be at a more consistent level. The change in this ratio indicates that an increase in the relative amount of ^{137}Cs occurred between the beginning and end of the log run on September 1, and suggests the sonde may have become contaminated in that borehole. Comparison of the 662-keV peak to the 1461-keV peak in the verification spectra leads to an estimated increase of about 2.6 cps in net activity for the 662-keV peak. However, the high “ambient” ^{137}Cs activity in the verification spectra (about 34 cps) masked this increase. When the sonde was next used in borehole C4176 on September 14, the pre-run verification spectra had a 662 keV peak with a net count rate of 3.7 cps. This was comparable to typical values commonly attributed to “shine” at other locations and was actually less than the 4 cps observed in the verification spectra when borehole C4176 was first logged on August 26. However, the minimum count rate for the 662-keV peak observed in log spectra collected on September 14 was 2.5 cps. This is roughly the same as the estimated net increase in ^{137}Cs activity observed on September 1, and leads to the conclusion that the sonde was contaminated in borehole C4671 on September 1, but that it was not detected until the logging system was next used in borehole C4176 on September 14.

The sonde was wiped down after the log run on September 14 and before logging on September 15. The wipes were found to be contaminated. Log data collected on September 15 appear to be free of the “residual” ^{137}Cs activity noted on September 14, and it is concluded that most, if not all of the contamination on the sonde was removed by routine wiping. The sonde was checked by RCTs after the log run of September 15, and no contamination was detected. After borehole C4176, the sonde was next used on September 22 in borehole C4665 (299-E25-95), a new groundwater well near AX Tank Farm. ^{137}Cs activity was noted in both pre- and post run verification spectra, and the borehole log indicates a maximum ^{137}Cs concentration of 3.3 pCi/g at 4 ft., decreasing to below the MDL at about 25 ft. On the next day, the borehole interval below 260 ft was logged and only intermittent traces of ^{137}Cs at the MDL were detected. This log profile is consistent with other logs in the area and does not appear to have been affected by any

contamination on the sonde. On September 27, the sonde was used to log borehole C4570 (699-17-27P) in the 100-K Area, and only intermittent traces of ^{137}Cs at the MDL were detected. These traces are common in all logs at Hanford. During routine log processing, a region of interest (ROI) is “forced” for the ^{137}Cs peak at 662 keV, and random fluctuations lead to intermittent traces where the net counts are at or slightly above the minimum detectable activity. When these spectra are examined, there is no evidence of a peak at 662 keV and the traces are not considered statistically significant.

Conclusion and Recommendations

Available evidence indicates the SGLS Gamma 4E sonde was most likely contaminated from logging operations conducted in borehole C4671 on September 1. However, the contamination was not detected because of high ^{137}Cs concentrations throughout the borehole and very high “ambient” ^{137}Cs activity at the surface. Because borehole C4671 was classified as “low risk,” no radiological survey was performed and the contamination was not detected. When the sonde was next used on September 14 in borehole C4176, the ^{137}Cs activity observed in the pre-run verification spectrum did not appear unreasonable for “shine,” but the persistent level of 2.5 to 3 cps throughout the logged interval clearly indicated the sonde was contaminated, and led the logging engineer to request a radiological survey of the wipes. Evaluation of verification spectra and log data collected on September 15 and afterward shows that the contamination was removed by routine wiping and that the sonde is no longer contaminated. Repeat logs in borehole C4176 indicate minor ^{137}Cs concentrations at 157 and 158 ft and near the bottom of the hole. The presence of contamination associated with fine-grained material on the centralizer after the log run on September 15 strongly suggests the presence of contaminated material on the inside of the 8-5/8-in. casing in borehole C4176. Before borehole C4176 is abandoned, a sample should be collected from the bottom of the borehole and analyzed for comparison with the sandy material from the centralizer.

The relatively high background gamma activity at 662 keV effectively masked the presence of contamination on the sonde, but Stoller logging personnel quickly detected it when the sonde was next used.

Evaluation of verification spectra and log data collected since September 15 clearly shows that the sonde is no longer contaminated. However the fact that contamination was picked up in a “low risk” borehole strongly suggests that all boreholes should be swabbed prior to logging, regardless of risk category. As an added precaution, geophysical logging personnel should have radiation detection instruments available at the logging site, so that suspected contaminated material can be more quickly identified and reported. These instruments are provided through the Grand Junction Office. It is not the intent to supplant the existing radiation control program, but to provide a means for early warning in low-risk situations where full-time RCT coverage is not practical.

References

Fecht, K.R., G.V. Last, and K.R. Price, 1977. *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells*, ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

Table 1. Summary of Gamma 4E Log Data 8/26/04 to 9/29/04

Date	Borehole	Depth Interval	Verification Spectra	¹³⁷ Cs (0662) & ⁴⁰ K (1461) data			Discussion of Results
				0662 cps	1461 cps	0662/1461	
8/26/04	C4176	53-0 22-17	DE281CAB DE281CAA	3.99 3.95	20.89 20.80	0.191 0.190	Initial log run in C4176. 0662 peak typical of ¹³⁷ Cs "shine." ⁶⁰ Co, ¹³⁷ Cs, and ²³⁸ U (^{234m} Pa) detected. Maximum ¹³⁷ Cs is 3,541 pCi/g at 24 ft.
8/30/04	C4260 299-E33-48	287-59	DE291CAB DE291CAA	1.13 1.14	20.83 21.01	0.054 0.054	Intermittent traces of ¹³⁷ Cs at or near MDL.
8/31/04	C4260 299-E33-48	138-115	DE301CAB DE301CAA	0.62 1.18	20.93 21.48	0.029 0.055	
8/31/04	C3426 299-W15-46	197-110 120-110	DE311CAB DE311CAA	0.40 0.74	20.79 20.16	0.019 0.037	Intermittent traces of ¹³⁷ Cs at or near MDL.
9/01/04	C4671	58-48 49-47 47-10 11-0 8-2	DE321CAB DE321CAA	34.36 33.96	21.11 19.29	1.627 1.760	Multiple SGLS runs with varying count times to deal with high gamma activity and detector dead time. High ¹³⁷ Cs in pre-run attributed to "shine." Extremely high levels of ¹³⁷ Cs detected throughout the borehole. Loss of efficiency masks increase in ¹³⁷ Cs on sonde in post run. Net increase in 0662 approximately 2.6 cps. Borehole swabbed on 9/04 – evidence of contamination found. PNLS sonde and external shield for HRLS also found to be contaminated.
9/14/04	C4176	241-66	DE331CAB DE331CAA	3.72 2.60	20.91 19.69	0.178 0.132	¹³⁷ Cs in verification spectra actually lower than previous (DE281CAB/CAA above). 0662 net counts varied from 2.51 to 7.12 cps, with average 3.39 cps and median 3.27 cps.
9/15/04	C4176	87-52	DE341CAB	1.18	20.56	0.057	Sonde was wiped down from previous day: wipes found to be contaminated (after DE341CAB). Evidence of borehole contamination from previous day discovered. Sandy material on centralizer found to be contaminated after log run. Borehole swabbed on 9/04 – no evidence of contamination.
9/22/04	C4665 299-E25-94	0-183 150-260	DE351CAB DE351CAA	3.81 3.20	20.93 20.68	0.182 0.155	Maximum ¹³⁷ Cs concentration 3.3 pCi/g at 4 ft – decreases to MDL at about 25 ft. ¹³⁷ Cs below MDL (0.22 pCi/g) at 1 ft. Observed contamination likely related to previous ground surface.
9/23/04	C4665 299-E25-94	259-326	DE361CAB DE361CAA	3.86 3.66	20.54 20.27	0.188 0.181	Traces of ¹³⁷ Cs at MDL (0.17 – 0.22 pCi/g).
9/27/04	C4570 699-17-27P	0-26 22-19	DE371CAB DE371CAA	0.69 0	19.91 20.47	0.035 0	Only intermittent traces of ¹³⁷ Cs at or near MDL.
9/28/04	C4176	0-235	DE381CAB DE381CAA	0.44 0.57	20.75 20.20	0.021 0.026	Results indicate bottom of 10 3/4-in. casing at 58 ft; lower extent of contaminated zone at 57 ft. ¹³⁷ Cs at or below MDL below 57 ft. Possible ¹³⁷ Cs from 156 to 157 ft.
9/29/04	C4176	240.4-220	DE391CAB DE391BAB DE391CAA	0.53 1.02 0.39	20.21 2.33 19.92	0.026 0.436 0.019	DE391BAB is "background" with sonde hanging in air. TD is 0.6 ft higher than 9/14/04. ¹³⁷ Cs at TD identical to 9/14/84. ¹³⁷ Cs generally at or below MDL. Possible ¹³⁷ Cs at 231 to 233 ft.

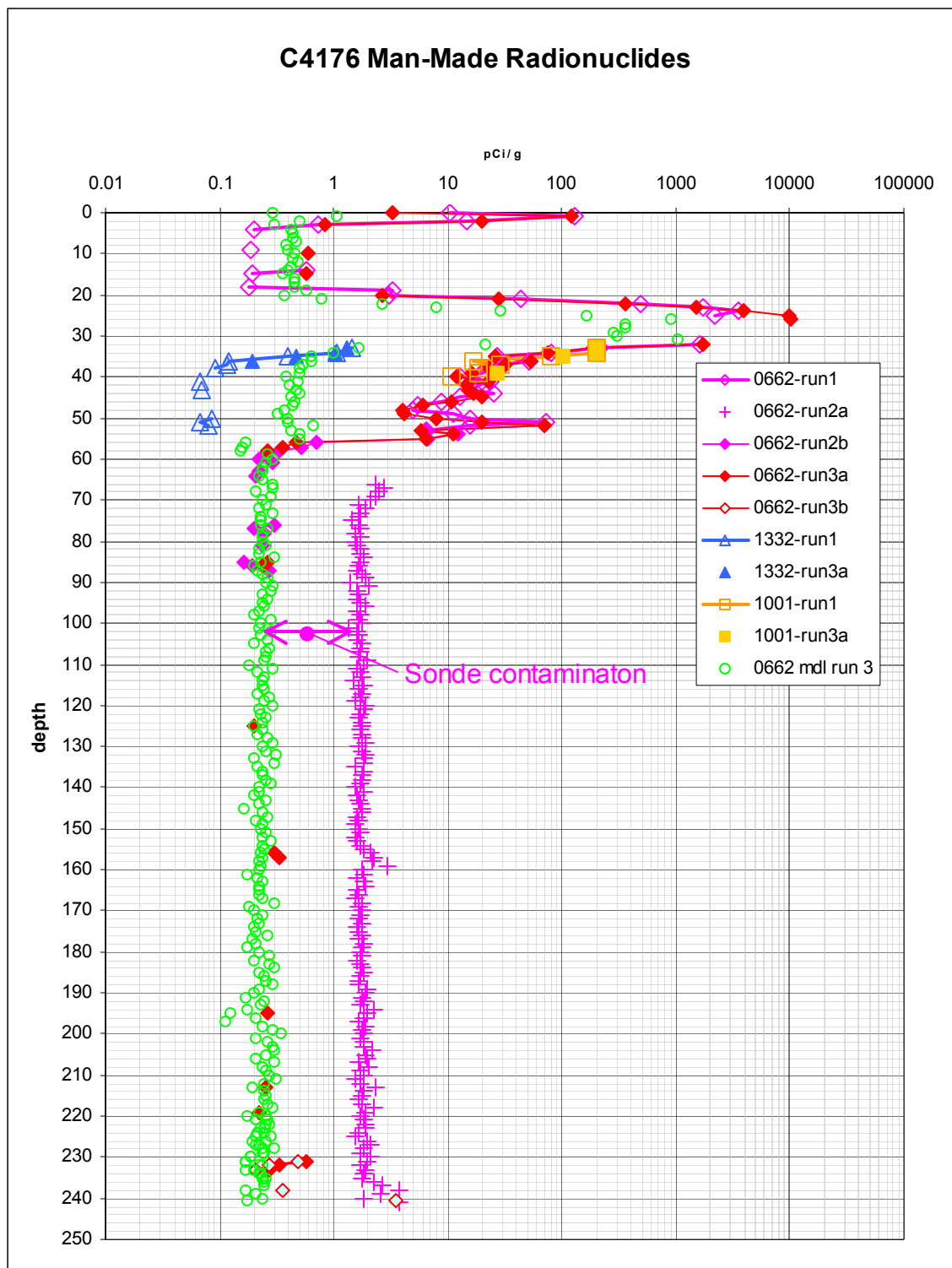


Figure 1. Preliminary Log Data for Borehole C4176